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Name:_____

SCH 4U Thermodynamics Test

1. Determine the heat of combustion of hexane given that 15.0 g of hexane (C_6H_{14}) can warm 25.000 l of water from 25.000 °C to 31.925 °C. DO NOT USE THE TABLES IN THE BOOK FOR THIS QUESTION (accept to perhaps check your answer)!!! Note that this is a multi-step problem - use appropriate format.

$C_6H_{14}(l) + \frac{19}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l) \quad \Delta H = ?$ ✓

$Q = mc\Delta T$ ✓

$Q = 25\,000 g \times 4.184 J/g°C \times (31.925 - 25.000)°C$ ✓

$Q = 724355\ J$ ✓

$Q = 724.355\ kJ$ ✓

$\frac{724.355 kJ}{15.0 g\ C_6H_{14}} \times \frac{86.2 g\ C_6H_{14}}{1 mol\ C_6H_{14}} = 4162.627 kJ/mol\ C_6H_{14}$ ✓ ✓ ✓ ✓

$\Delta H = -Q$ ✓

$\Delta H = -4162.627 kJ/mol\ C_6H_{14}$ ✓

$C_6H_{14}(l) + \frac{19}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l)$

$\Delta H = -4162.627 kJ$ ✓

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(1)

2. Using heats of formation from pg 799 in your text and that $\Delta H^\circ_{Al2O3(s)} = -1866.44$ kJ and $\Delta H^\circ_{Al4C3(s)} = -30.9$ kcal determine the heat of reaction for: (methane)

↳ $-30.9 \text{ kcal} \times \frac{4.184 \text{ kJ}}{\text{kcal}} = -129.29$ kJ

$2Al_2O_3(s) + 3CH_4(g) \Rightarrow Al_4C_3(s) + 6H_2O(g)$

$\Delta H = [\Delta H^\circ_{Al_4C_3(s)} + 6\Delta H^\circ_{H_2O(g)}] - [2\Delta H^\circ_{Al_2O_3(s)} + 3\Delta H^\circ_{CH_4(g)}]$

$\Delta H = [-129.29 \text{ kJ} + 6(-241.8 \text{ kJ})] - [2(-1866.44 \text{ kJ}) + 3(-74.4 \text{ kJ})]$

$\Delta H = 2375.99 \text{ kJ}$

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(1)

3. The heat of combustion of octane ($C_8H_{18}(l)$) is -5470.1 kJ. Use $\Delta H^\circ_{CO2(s)} = 393.5$ kJ, $\Delta H^\circ_{H2O(l)} = 285.8$ kJ and the heat summation rule to determine the heat of formation of octane. Once again DO NOT USE THE TABLES IN THE BOOK FOR THIS QUESTION (accept to perhaps check your answer)!!!

$C_8H_{18}(l) + \frac{25}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$

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$\Delta H = [8\Delta H^\circ_{CO_2(g)} + 9\Delta H^\circ_{H_2O(l)}] - [\Delta H^\circ_{C_8H_{18}(l)} + \frac{25}{2}\Delta H^\circ_{O_2(g)}]$

$-5470.1 \text{ kJ} = [8(-393.5 \text{ kJ}) + 9(-285.8 \text{ kJ})] - [\Delta H^\circ_{C_8H_{18}} + \frac{25}{2}(0)]$

$\Delta H_{C_8H_{18}} = -5720.2 \text{ kJ} + 5470.1 \text{ kJ}$

$\Delta H_{C_8H_{18}} = -250.1 \text{ kJ}$

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(1)

4. Determine the mass of steam produced by the heating of 500 mL of water starting at 20 °C by the thorough combustion of 5.0 ~~10.0~~ g of benzene ($C_6H_6(l)$). Try pg 799 & 307 for relevant values. Do not use Hess' Law

$C_6H_6(l) + 15/2\,O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$ $\Delta H = ?$ ✓

$\Delta H = [6\Delta H^\circ_{CO_2(g)} + 3\Delta H^\circ_{H_2O(l)}] - [\Delta H^\circ_{C_6H_6(l)} + 15/2\,\Delta H^\circ_{O_2(g)}]$ ✓

$\Delta H = [6(-393.5kJ) + 3(-285.8kJ)] - [49.0kJ + 15/2(0)]$ ✓

$\Delta H = -3267.4kJ$ ✓

$Q = -\Delta H$ ✓

$Q = 3267.4kJ/mol\ C_6H_6(l)$ ✓

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$$5.0g\ C_6H_6 \times \frac{1mol\ C_6H_6(l)}{78.12g\ C_6H_6(l)} \times \frac{3267.4kJ}{1mol\ C_6H_6(l)} = 209.127kJ$$ ✓ ✓ ✓ ✓ available heat

$Q = mc\Delta T$ ✓

$Q = 500g \times 4.184J/g°C \times 80°C$ ✓

$Q = 167360\ J$ ✓

$Q = 167.360kJ$ ✓ ← heat required to warm water

available − required = remaining ✓

$209.127kJ - 167.360kJ = 41.767\ kJ$ ✓ remaining (to produce steam)

$Q = Lvm$ ✓

$m = \frac{Q}{Lv}$

$m = \frac{41.767kJ}{\frac{40.8kJ}{1mol} \times \frac{1mol}{18.02g}}$ ✓ ✓

$m = 18.447g$ ✓

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5. Using Hess' Law determine heat of formation of urea, $CO(NH_2)_2(s)$ from the following information:

① the heat of formation of ammonia, $NH_3(g)$ is -45.9 kJ

② the heat of combustion of acetic acid, $CH_3COOH(l)$ is -925.8 kJ

③ the heat of formation of methane ($CH_4(g)$) is -74.4 kJ

④ $CO(NH_2)_2(s) + H_2O(l) + CH_4(g) \Rightarrow CH_3COOH(l) + 2NH_3(g)$ $\Delta H° = 169.1$ kJ

⑤ the heat of formation of $CO_2(g)$ is -393.5 kJ

⑥ the heat of formation of H_2O (l) is -285.8 kJ

Find $C(s) + \frac{1}{2}O_2(g) + N_2(g) + 2H_2(g) \rightarrow CO(NH_2)_2(s)$ ✓

Given ✓① $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$ ✓ $\Delta H = -45.9$ kJ

✓② $CH_3COOH(l) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ $\Delta H = -925.8$k

✓③ $C(s) + 2H_2(g) \rightarrow CH_4(g)$ ✓ $\Delta H = -74.4$ kJ

16 ✓④ $CO(NH_2)_2(s) + H_2O(l) + CH_4(g) \rightarrow CH_3COOH(l) + 2NH_3(g)$ $\Delta H = 169.1$kJ

✓⑤ $C(s) + O_2(g) \rightarrow CO_2(g)$ ✓ $\Delta H = -393.5$kJ

✓⑥ $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ ✓ $\Delta H = -285.8$kJ

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rev ④ ~~$CH_3COOH(l) + 2NH_3(g)$~~ $\rightarrow CO(NH_2)_2(s) + H_2O(l) + CH_4(g)$ ✓ $\Delta H = -169.1$k

rev ② ~~$2CO_2(g) + 2H_2O(l)$~~ $\rightarrow CH_3COOH(l) + 2O_2(g)$ ✓ $\Delta H = 925.8$k

✓✓ rev ③ ~~$CH_4(g)$~~ $\rightarrow C(s) + 2H_2(g)$ ✓ $\Delta H = 74.4$kJ

2× ① $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ ✓ $\Delta H = -91.8$kJ

2× ⑤ ~~$2C(s) + 2O_2(g)$~~ $\rightarrow 2CO_2(g)$ ✓ $\Delta H = -787.0$k

⑥ ~~$H_2(g) + \frac{1}{2}O_2(g)$~~ $\rightarrow H_2O(l)$ ✓ $\Delta H = -285.8$kJ

$C(s) + \frac{1}{2}O_2(g) + N_2(g) + 2H_2(g) \rightarrow CO(NH_2)_2(s)$ $\Delta H = -333.5$k ✓✓

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